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HIGH STRENGTH, BIO-COMPATIBLE TISSUE ADHESIVE AND
METHODS FOR TREATING VIGOROUSLY BLEEDING SURFACES

BACKGROUND

The present invention relates generally to adhesives, more specifically it relates to medical adhesives, and particularly it relates to tissue adhesives which exhibit high bio-compatibility, excellent tensile properties, are bio-absorbable, do not interfere with the healing processes and are easily applied to various tissues. The present invention is also particularly well suited for controlling complex, vigorous bleeding emanating from large surface areas, specifically the visceral organs, lungs and the vascular system.

The use of adhesive compounds in wound sealing and hemorrhage control dates back to the sixteenth century. Early sealants consisted of rosewater, turpentine and eggs and were used in conjunction with ligatures. *Biologic and Synthetic Polymer Networks*, Ed. O. Kramer; Elsevier Applied Science, New York (1988). While such techniques offered marked improvement over cautery, little effort was made to advance the art until the Spanish Civil war when plasterized cotton was introduced. Leo Mandelkern, *An Introduction to Macromolecules* 2nd ed.; Springer Verlag, New York (1983). Early cotton-based adhesives were little more than surgical packings and could not control large, profusely bleeding visceral surfaces.

Subsequent wars brought new experiments with adhesives to aid in controlling the massive, vigorously bleeding hemorrhages associated with battlefield injuries. In the 1940s, trauma surgeons began experimenting with fibrin sealants, however, these did not possess the strength required to adequately control vigorous bleeding wounds and W.W.II field hospitals returned to plasterized cotton. Turner Alfrey et al., *Organic Polymers*; Prentice Hall, New Jersey (1967). Technological advances in polymer chemistry led to the development of cyanoacrylates that were first used as tissue adhesives in the Vietnam war. Since that time, moderate advances have been made in the development of modern tissue adhesives, but none have adequately addressed the technical and biological complexities associated with vigorous bleeding homeostasis.

Severe traumatic injuries result in massive intra-abdominal hemorrhages in approximately 10 to 25% of cases. Uncontrolled bleeding and transfusion-associated complications make up the majority of deaths in these patients. The current recommended standard of care for treating intra-abdominal bleeding is a process called packing which utilizes pressure and nylon gauze to contain the blood flow. A. Sauaia, et al., *Epidemiology of Trauma Deaths: a Reassessment*, Journal of Trauma (February 1995). However, in spite of advances in nearly every other branch of medicine,